well be the mainstay of the life sciences microgravity experiments in the shuttle middeck while the Space Station is being assembled.

Unique flight hardware, designed to support specific experiments on the Neurolab Mission, includes the Neurolab biotelemetry system (NBS) and a sophisticated system to measure and record neural coding signals of place and direction in the microgravity environment. The NBS, based on commercially available hardware, was developed to monitor heart rate, deep body temperature, and activity for 12 rats housed in one of the payload's two RAHF systems (see second figure). The hardware that measures and records neural codings monitored the performance of freely behaving rats on specialized experiment apparatuses during testing sessions inside the GPWS.

Fig. 2. Ensemble neural coding of place and direction in Zero-G experimental animal, with associated test hardware.

ARC's engineering, science, and operations personnel have successfully managed hardware development, functional testing, biocompatibility testing, and delivery of a highly complex array of flight hardware to support this last Spacelab Mission in commemoration of the "Decade of the Brain."

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Advanced Life Support Research and Technology Development Activities

Mark Kliss

Ames Research Center carries out research and development of new technologies that will enable the human exploration and development of space. These activities will reduce life-cycle costs, improve operational performance, promote self-sufficiency, and minimize the expenditure of resources in future space exploration, such as a human mission to Mars. Advanced Life Support technologies for a human Mars mission are depicted in the figure. There are also significant opportunities for Earth application of the developed technologies. The following are some of the key examples of these activities.

Power consumption is a key problem facing carbon dioxide (CO_2) removal technologies for long-duration spaceflight. There are problems with efficiency in using the current sorbent-based techniques to perform the carbon dioxide/water (CO_2/H_2O) split. This research seeks to develop high-efficiency CO_2 removal technologies for closed-loop regenerative systems by improving the CO_2/H_2O separation. Data on the influence of water on the adsorption of CO_2 and trace contaminants show significant reduction in the capacity of sorbents and the possibility of elution back into the cabin environment. In FY97, research on new materials and operating procedures has made significant contributions toward mitigating this safety problem. New knowledge on adsorption processes has also led to a novel passive/low-power method of extracting and pressurizing a nitrogen-argon mixture from the Martian atmosphere. This mixture would be suitable as a carrier/sweep gas for instruments used on planetary probes.

In situ resource utilization (ISRU) is an enabling technology for both robotic and human missions. In robotic missions, the in situ production of consumables from local resources (carrier gas,

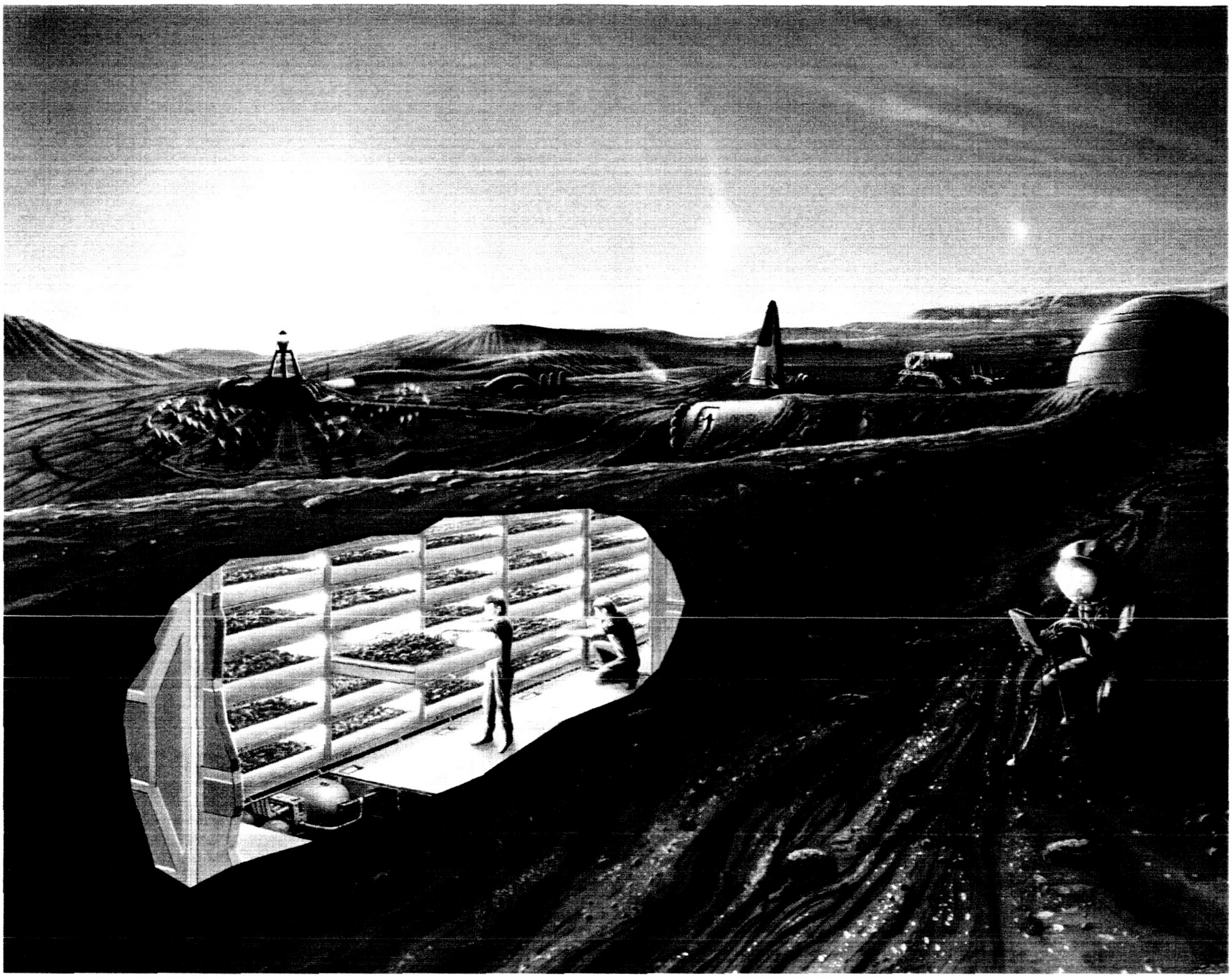

Fig. 1. Artist's rendition of Advanced Life Support technologies for a human Mars mission.

calibration gas, propellants) can extend the range and duration of science payloads. In robotic sample-return missions, fuel and oxygen for the return voyage can be produced locally; such an approach is being considered for the Mars sample-return mission. For human missions, the production of consumables for life support and propulsion from planetary resources significantly reduces cost and risks.

At Ames the core processes related to "mining the atmosphere of Mars" are being researched. Efforts include (1) energy-efficient ways of compressing the predominantly CO_2 atmosphere of Mars for chemical processing needs and utility gas, (2) separation of nitrogen/argon buffer gas for instruments and life support, (3) production of oxygen from CO_2 electrolysis, (4) evaluation of water collection methods, and (5) development of microsensors for ISRU applications. FY97 research has led to the development of a test-bed which has successfully demonstrated Mars atmospheric compression, oxygen generation, and microsensing of oxygen (O_2) and CO_2.

Human and food wastes are not currently recycled, and are key elements in the design of advanced life-support systems that approach self-sufficiency. Both supercritical water oxidation (SCWO) and incineration processors have been developed and are currently under evaluation. Key issues that are being addressed include waste preparation and process feed and product stream clean-up, with a special focus on the acid gases and other trace contaminants produced. A prototype incinerator was delivered to Johnson Space Center as part of an extended closed 90-day manned chamber test. All product gases met Spacecraft Maximum Allowable Contaminant standards, and the CO_2 product gas was used to supply CO_2 to a wheat crop included in the 90-day closed test. The U.S. Navy has expressed interest in SCWO technology because of its potential for reducing hazardous liquids to CO_2 and H_2O while ships are at sea.

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U.S. Army Application for NASA Technology

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The purpose of this project was to use NASA technology to assist the U.S. Army in the assessment of motion sickness incidences in the command and control vehicle (C2V). The NASA technology utilized is U.S. Patent No. 5,639,436, Autogenic-Feedback Training Exercise system and method. During this study we determined the frequency and severity of motion sickness in personnel during a field exercise in the C2V. This vehicle contains four workstations where military personnel are expected to perform command decisions in the field during combat conditions. Eight active duty military men (U.S. Army) at the Yuma Proving Grounds in Arizona participated in this study. On the first day, all subjects were given baseline performance tests while their physiological responses were monitored. On the second day of their participation, subjects rode in the C2V while their physiological responses and performance measures were recorded. Self-reports of motion sickness were also recorded, with only one subject experiencing two incidences of emesis. Seven out of the eight subjects reported other motion sickness symptoms; most predominant was the report of drowsiness, which occurred a total of 19 times. The table summarizes symptom reports, hours of sleep obtained on the previous night, seat position in the C2V, and previous experience in this or other tracked vehicles.

Changes in physiological responses were observed relative to motion sickness symptoms reported and the different environmental conditions (i.e., level, hills, and gravel) during the field exercise. The subject who reported the most symptoms (subject 3), and the one who reported no symptoms at all (subject 6), both rode in the C2V on the same day. The first figure shows the physiological data of both individuals which are plotted as 1-minute averages across time. C2V courses are represented as

Table 1. Motion sickness symptoms during the command and control vehicle (C2V) field exercise

I.D.	VMT	TMP	DIZ	HAC	DRZ	SWT	PAL	SAL	NSA	ED	EA	Previous experience	Seat position	Hours sleep
# 1					3							Yes	4	6.5
# 2					2							No	1	4.5
# 3	2	4	3		4	3	1	1	3			No	1	4.0
# 4					1							Yes	4	6.5
# 5			3	1	1				1			No	1	5.0
# 6												Yes	4	4.5
# 7		1		1	4	1		1	1	2	2	No	1	7.0
# 8		2	2		4	1						Yes	4	6.0
Total	2	7	8	2	19	5	1	2	5	2	2			